

**BANKING CLUSTERING STUDY BASED ON FUZZY C-MEAN AND FUZZY GUSTAFSON KESSEL**

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**Abstract:**

The banking sector as one of the economic drivers plays an important role in society. Over time, bank operations did not only raise funds from the public but were more complex. The development of the banking industry can be seen from the number of banks in Indonesia that have spurred the level of competition. Of course, the bank must pay attention to its health. The use of bank soundness level parameters or RGEC combined with clusters is interesting to study. By using the cluster method, banks can be classified based on the parameters of their health level. This study aims to analyze the RGEC-based bank grouping classification generated by the Fuzzy C-Means and Fuzzy Gustafson Kessel clustering analysis using financial ratio data on 80 conventional banks in Indonesia. The software used in this study is Matlab r2015b. The results showed that the FCM clustering had a smaller standard deviation than FGK so that the first cluster in the FCM showed that the banks were in good condition compared to the other clusters even though the overall condition of banks in Indonesia was good when viewed from their financial performance.

**Keywords:**

Fuzzy C-Means, Fuzzy Gustafson Kessel, Banking



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**INTRODUCTION**

The banking sector, which is now growing in existence, has long been an interesting subject of study to be used as a source of research because of its important role as a driving force of the economy (Sulistyan, Ermawati, Hidayat, Lukiana, & Kasno, 2019). In Act Number 10 of 1998 concerning Banking, a bank is stated as a business entity that collects funds from the public in the form of deposits and distributes them to the public in the form of credit and / or other forms in order to improve people's lives. Over time, bank operations did not only raise funds from the public but were more complex. A bank is a type of financial institution that performs various services, such as providing loans, circulating currency, controlling currency, acting as a storage place for valuable objects, financing the business of companies and others. Good bank performance and a healthy bank condition are needed in determining where a person or company will invest their capital or perform other banking services (Abdurrahman, 2001).

The results of the factors affecting the soundness level are in the form of a bank soundness level composite rating which is determined based on a comprehensive and structured analysis of the ranking of each factor as referred to in Article 8 paragraph (2), paragraph (3), paragraph (4), and paragraph (5) in Bank Indonesia Circular Letter No. 13/24 / DPNP dated 25 October 2011 by taking into account the materiality and significance of each factor. The large number of companies in the banking sub-sector creates a form of competition in improving performance and expanding market share, by using the cluster method, the number of existing banks can be grouped into clusters which are similar in terms of the bank soundness ratio so that it will be seen which bank groups have the same characteristics.

Cluster analysis is included in the multivariate analysis technique with interdependent methods. This technique aims to organize information / summarize data by grouping objects based on certain similar characteristics. Thus, Cluster Analysis or clustering has the goal of classifying data from a series of observations into subsets (called clusters). Long cluster analysis (Tryon, 1939, 1957) includes several different algorithms and methods for grouping similar objects into their respective categories. A common question that faces researchers in many fields of research is how to organize the observed data into meaningful structures, that is, to develop a taxonomy. Cluster analysis can be used to find data structures without providing an explanation / interpretation. In other words, cluster analysis only finds data structures without explaining why they exist.

Grouping analysis is data analysis which intends to determine groups or groups of data based on the similarity of characteristics so that the further development of cluster analysis is to consider the membership

level which includes fuzzy sets as the weighting basis for grouping which is called fuzzy clustering (Rahmatika, Suparti, & Safitri, 2015). There are many grouping methods in Fuzzy clustering, one of which is Fuzzy C-Means (FCM) and Fuzzy Gustafson Kessel (FGK). After grouping the two methods, the next step is to find the optimum number of clusters based on the XB index and determine the best method by looking at the icdrate criteria, then perform a MANOVA analysis to determine the differences in the characteristics of each cluster.

This research is supported by several studies related to the RGEC ratio, including Daryanto, Utami, and Rakhmawati (2018), Devianto and Dwiasnati (2018), Nicola, Manalu, and Hutapea (2017), Minarrohmah, Yaningwati, and Nuzula (2014), Andriyani, Pebrica, Mayasari, and Aryani (2018), Dewi and Candradewi (2018). Meanwhile Amalia, Widodo, and Oktaviana (2016) also examined the health of banks with the CAMELS ratio but also clustered the banks. Rahmatika et al. (2015) also used the cluster method but not for banking.

The development of the banking industry can be seen from the number of banks in Indonesia that have spurred the level of competition. Of course, the bank must pay attention to its health. The use of bank soundness level parameters combined with clusters is interesting to study. By using the cluster method, banks can be classified based on parameters of their health level.

## METHOD

This research is a descriptive study, namely collecting, interpreting, and analyzing data by performing calculations based on theory with objective data that occurs so that it can provide a complete picture of the research problem and its resolution efforts. The population in this study are all conventional banks operating in Indonesia. The sample in this study was taken based on the availability of data and the ease of obtaining it or it is called the convenience sampling method. The type of data is secondary data in the form of bank financial reports such as statements of financial position, income statements, and others. Sources of data were obtained from the official website of the Financial Services Authority (OJK), the Indonesia Stock Exchange and the Bank's Website in the form of annual financial reports for banks, especially conventional banks in 2019. Research variables based on the RGEC aspect are limited to the aspects of Risk, Earnings and Capital. The Risk aspect consists of two variables, namely the variable Credit Risk and Liquidity Risk. The Earnings aspect consists of four variables, namely the Return on Assets (ROA) variable, Operational Expenses on Operating Income (BOPO), and Net Interest Margin (NIM). The Capital aspect consists of one variable, namely the Capital Adequacy Ratio (CAR). The results of the calculation of RGEC-based ratios will be processed using the Fuzzy C-Means Cluster method with the formula as in equations 1 and 2 in the theoretical study or can be shown below:

$$P_t(X; U, V) = \sum_{i=1}^n \sum_{k=1}^c (\mu_{ik})^w (d_{ik})^2$$

$$d_{ik} = d(x_k - v_i) = [\sum_{j=1}^m (X_{ij} - V_{kj})^2]^{\frac{1}{2}}$$

In addition, this ratio is included in the Fuzzy Gustafson Kessel Cluster method with the following formula:

$$J(X; U, V, \{A_i\}) = \sum_{i=1}^c \sum_{k=1}^n (\mu_{ik})^w D_{ikA_i}^2$$

$$D_{ikA_i}^2 = (X_k - V_i)^T A_i (X_k - V_i)$$

so that the clusters will be formed, each of which has similarities to one another. The results of data processing using the Cluster Fuzzy C-Means and Gustafson Kessel method will show how many clusters are formed and how many members of each cluster so that it will be known which cluster method is the best, namely the one with the smallest standard deviation.

## RESULTS AND DISCUSSION

The clustering or grouping of banks in Indonesia will be divided into 5 clusters where each cluster is labeled with a number 1-5. The bank health ratio data that has been obtained will be grouped using the FCM and FGK cluster methods in the Matlab r2015b software. The results of the grouping are as follows:

Table 1. Cluster results using the FCM method.

Cluster	Bank		
1	1. Bank Mandiri	16. Bank Kalteng	31. Bank Oke Indonesia
	2. BRI	17. Bank Lampung	32. Citibank
	3. BNI	18. Bank Maluku Malut	33. Bank KEB Hana
	4. Bank Mandiri Taspen	19. Bank Nagari	34. Bank Maspion
	5. Bank Bali	20. Bank NTT	35. Bank Mega
	6. Bank Jawa Barat	21. Bank Riau Kepri	36. Bank Maybank Indonesia
	7. Bank Bengkulu	22. Bank Sulselbar	37. Bank Mestika Dharma
	8. Bank DKI	23. Bank Sulteng	38. Bank OCBC NISP

	9. Bank Jambi	24. Bank Sultra	39. Bank SBI Indonesia
	10. Bank Jateng	25. Bank Sulutgo	40. Bank Woori Saudara
	11. Bank Jatim	26. Bank BNP Paribas Indonesia	41. Bangkok Bank
	12. Bank Kalbar	27. China Construction Bank	42. Amar Bank Indonesia
	13. BTPN	28. Bank CIMB Niaga	43. Bank Bisnis Indonesia
	14. BCA	29. Bank Danamon	44. Bank Jasa Jakarta
	15. Bank Panin	30. Bank ICBC Indonesia	45. Bank Sumut
2	1. Bank Digital BCA		
3	1. Bank Artha Graha Internasional	3. Bank Commonwealth	5. Bank Artos Indonesia
	2. Bank Kaltimara	4. Bank HSBC Indonesia	6. JP Morgan Chase
4	1. BTN	10. Bank Ganesha	19. Bank Resona Perdania
	2. BRI Agroniaga	11. Bank IBK Indonesia	20. Bank Sinarmas
	3. Bank Banten	12. Bank Mayapada	21. Bank UOB Indonesia
	4. Bank Kalsel	13. Bank Mayora	22. Bank Victoria Internasional
	5. Bank Papua	14. Bank Multi Arta Sentosa	23. Bank Fana Indonesia
	6. Bank Bukopin	15. Bank Nationalnobu	24. Bank Kesejahteraan Ekonomi
	7. Bank Capital Indonesia	16. Bank of India Indonesia	25. Bank Sahabat Sampoerna
	8. Bank CTBC Indonesia	17. Bank Permata	
	9. Bank DBS Indonesia	18. Bank QNB Indonesia	
5	1. Bank Mizuho Indonesia	2. Bank Shinhan Indonesia	3. MUFG Bank

Source: Data processed, 2020

Based on table 1, it can be seen that the 1st cluster has the most members, namely 45 banks, while the cluster with the least members is the 2nd cluster, with only 1 bank member. Grouping based on FGK is also carried out using the Matlab r2015b program as well as the FCM in FGK will be divided into 5 groups that have similarities or are called clusters. The results of the cluster by means of FGK resulted in members of each cluster as follows:

Table 2. Cluster Results using the FGK Method

Cluster	Bank		
1	1. BRI Agroniaga	5. Bank IBK Indonesia	9. Bank Fana Indonesia
	2. Bank BantenI	6. Bank Multi Arta Sentosa	10. Bank Oke Indonesia
	3. Bank BNP Paribas Indonesia	7. Bank QNB Indonesia	11. Bank Victoria Internasional
	4. Bank Bukopin	8. Amar Bank Indonesia	
2	1. Bank Jateng	4. Bank Mestika Dharma	7. Bank Jasa Jakarta
	2. Bank Sulteng	5. Bank SBI Indonesia	8. JP Morgan Chase
	3. Bank NTT	6. Bank Bisnis Indonesia	9. MUFG Bank
3	1. Bank Mandiri	15. Bank Papua	29. Bank DBS Indonesia
	2. BRI	16. BCA	30. Bank Ganesha
	3. BNI	17. Bank Lampung	31. Bank ICBC Indonesia
	4. Bank Mandiri Taspen	18. Bank Maluku Malut	32. Bank Mayapada
	5. Bank Bali	19. Bank Nagari	33. Bank KEB Hana
	6. Bank Jawa Barat	20. Bank Sumut	34. Bank Mayora
	7. Bank Bengkulu	21. Bank Riau Kepri	35. Bank Nationalnobu
	8. Bank DKI	22. Bank Capital Indonesia	36. Bank OCBC NISP
	9. Bank Jambi	23. Bank CIMB Niaga	37. Bank Permata
	10. Bank Kalsel	24. Bank Sultra	38. Bank Resona Perdania
	11. Bank Jatim	25. Bank Sulutgo	39. Bank UOB Indonesia
	12. Bank Kalbar	26. Bank Danamon	40. Bank Kesejahteraan Ekonomi
	13. Bank Kalteng	27. China Construction Bank	
	14. BTN	28. Bank CTBC Indonesia	
4	1. Bank Kaltimara	6. Bank Maspion	11. Bank Panin
	2. Bank Sulselbar	7. Bank Maybank Indonesia	12. Bank Sinarmas
	3. Bank Artha Graha Internasional	8. Bank Woori Saudara	13. Bank Mega
	4. Bank Sahabat Sampoerna	9. Bank Mizuho Indonesia	14. Bangkok Bank
	5. Bank HSBC Indonesia	10. BTPN	15. Citibank
5	1. Bank Commonwealth	3. Bank Shinhan Indonesia	5. Bank Digital BCA
	2. Bank of India Indonesia	4. Bank Artos Indonesia	

Source: Data processed, 2020

From table 2 of the cluster members above, it can be seen that the most cluster members using the FGK method are the 3rd cluster, which is 40 members, while the cluster with the least members is the 5th

cluster with 5 members. Iteration how each fuzzy, namely FCM and FGK converge or get the best results. The graph in the figure shows the objective function of FCM converging when it reaches under 200 iterations, while for FGK it is in the 200th iteration over 200. The resulting error value is  $10^{-8}$  or 0.00000001, where the smaller the error value, the more convergent the data obtained.

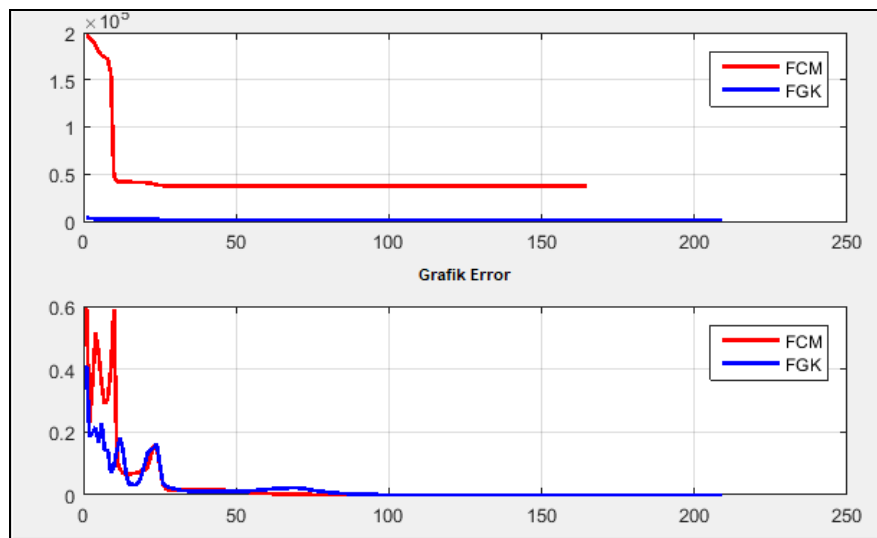


Figure 1. Graph of Objective Functions, Error and Number of Iterations

The cluster plot of both methods can be seen from the matlab application and can be replaced for the axes (x, y) with the existing variables. In the plot image below, it will appear that each cluster has a different color.

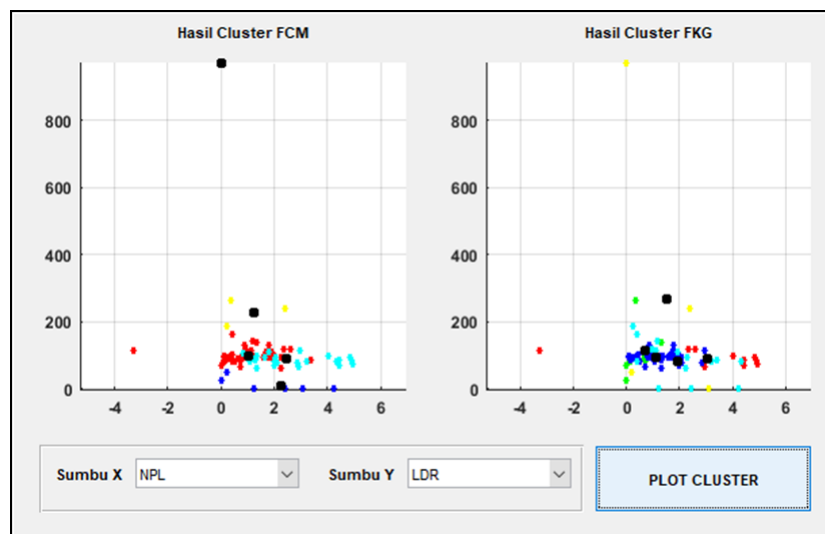


Figure 2. The FCM and FGK cluster plot

Grouping based on bank health ratios using the FCM and FGK cluster methods produces different members in each cluster. The Fuzzy C-Means (FCM) method is better than the Fuzzy Gustafson-Kessel (FGK) method. By knowing the FCM cluster method is the right method for conventional banking health ratio data in Indonesia, it can be analyzed how the condition of the bank in each cluster formed by the FCM cluster method. The following is an analysis of each ratio or variable in this study:

- a. NPL (Non Performing Loan) The NPL provides an overview of non-performing loans at banks. An increase in non-performing loans at banks will have a bad impact on the health of the bank. Therefore, the bank is expected to maintain its NPL position so that it is not high. Bank Indonesia Regulation Number 6/10 / PBI / 2004 dated April 12, 2004 concerning the Health Assessment System for Commercial Banks establishes a fair threshold for NPL value, namely  $\leq 5\%$  of the total loan portfolio. NPL will also result in higher bank income NPL, the bank's income will decrease so that the bank will have difficulty in carrying out its function.

In the results of the cluster, it is known that the 1st cluster has an NPL value of -3.3% - 3.39% and if it is taken the average yields an NPL of 0.95%, this indicates that the banks in the 1st cluster are below 5% or credit problems that are owned are relatively small and can be handled properly. Different results were obtained from the second cluster because in this cluster the members gathered were only 1 member,

namely BCA Digital Bank where the NPL value was 0. This indicates that the bank does not have non-performing loans but it also means that the bank does not have interest income from credit. For the third, fourth and fifth clusters, respectively, have an average NPL value of 1.86% for the 3rd cluster and 2.72% for the 4th cluster and 1.00% for the 5th cluster. This result means that the bank is still below the fair value limit of NPLs so that the condition of the bank is said to be still able to manage credit problems properly. Overall, from the bank ratio data, the NPL value is still below 5%, meaning that banks in Indonesia can control their non-performing loans.

**b. LDR (Loan to Deposit Ratio)**

LDR in a bank is a ratio that can broadly measure a bank's ability to meet short-term obligations. LDR needs to be managed properly because if it is too high, the bank will not be able to cover its obligations to customers, while if it is too low, the bank has relatively low income because as it is known, the bank earns income mainly from loans extended. Based on the provisions of Bank Indonesia as stipulated in PBI No. 17/11 / PBI / 2015 dated 25 June 2015 states that the upper limit of the LDR is 92% while the lower limit is at 78%.

From the results of the FCM data cluster, it can be seen that in the 1st cluster the average LDR value is 98.6%, this is classified as having met the lower threshold but is above the upper limit of the LDR. In this group, banks are still able to cover their obligations properly and still have income. However, if the value is higher, it is feared that it will become a problem for the bank in fulfilling its obligations, the bank could further collapse if its value continues to rise. If the LDR value is high, banks should start looking for other funding alternatives apart from lending. The highest LDR value is seen in the second cluster where BCA Digital Bank reaches an LDR value of 971.65%, with this value the risk of collapse is inevitable. The opposite result in the 3rd cluster LDR is relatively low, far below this indicates that many bank funds are not channeled optimally in the form of credit.

**c. ROA (Return on Asset)**

ROA is one of the profitability ratios that measures the company's ability to generate profits from the use of all its resources or assets. The higher the ROA, the better the company's performance and further as a decision-making decision what business expansion is needed and attracts investors. According to Bank Indonesia Circular No. 6/23 / DPNP dated May 31, 2004, the minimum ROA limit is 1.5%. From the results of grouping, the average ROA value in the first cluster is 2.3%, indicating that the banks in the first cluster generate optimal profits because the bank is able to manage existing assets well. Sub-optimal results are in the 2nd and 3rd clusters where the cluster members have a negative ROA value, which means the bank's ability to generate profits is not optimal.

**d. BOPO (Operational Expenditures against Operating Income)**

BOPO is a ratio that describes the efficiency of banks in running their business. Operational expenditure, in this case, is the interest expense charged to customers and operating income is the interest earned. The higher the costs incurred to generate income, the more inefficient the bank is operating. The minimum limit of OEIO according to Bank Indonesia is 85%, seen from the cluster data it produces an average BOPO value in the 1st cluster, which is 76.2%, indicating that banks in the 1st cluster are able to generate income efficiently with the use of appropriate operating costs. so that bank operations run well. Inappropriate use of operational costs results in high BOPO values above 100% in clusters 2,3 and 4 so it is necessary to reduce unnecessary operational costs so that the value is not too high. The increase in BOPO as a result of which is competition between banks to attract customers so that it requires fees for promos and prizes, besides that technology has not been applied to banks also makes bank operations ineffective in running it

**e. NIM (Net Interest Margin)**

The NIM standard by Bank Indonesia is 6%, meaning that the greater the value, the increase in interest income on productive assets managed by the bank will result in a smaller bank condition experiencing financial problems. The existence of promos in the provision of credit causes banks to compete in order to maintain the level of interest income.

The NIM in the cluster formed using the FCM method, namely in the 1st cluster an average of 5.85% is quite good, almost close to the minimum limit, if seen from the NIM members in the 1st cluster there are those who have met the minimum NIM limit, even Amar Bank Indonesia booked a NIM of 19.3%, which means that in the 1st cluster the bank has been able to maintain its interest income and is in a stable condition. Overall NIM in Indonesia in 2019 tends to decline because many banks prefer credit quality rather than seeking interest income.

**f. CAR (Capital Adequacy Ratio)**

CAR is the minimum capital adequacy ratio that shows the ability of banks to provide funds that are used to overcome possible risk of loss. The higher the CAR, the better the bank is in facing the risk of loss. In Bank Indonesia regulation number 15/12 / PBI / 2014 concerning the minimum capital requirement for commercial banks, a lower CAR threshold value is set at 8%. From the cluster results, the average CAR in the first cluster is 25.1%, this indicates that the banks in this cluster have sufficient

capital to face the risk of loss. Overall, CAR in Indonesia is optimal and is above the lower threshold value of 8%. The CAR table for each cluster member is as follows:

## CONCLUSION

The FCM and FGK cluster methods have resulted in 5 clusters and the result of standard deviation results in smaller FCM values than FGK, so that FCM is better used for banking data. Judging from the NPL ratio is quite good in cluster 1. The LDR in cluster 1 has met the lower threshold but is above the upper limit of the LDR, and looks high in cluster 2, but on the other hand in cluster 3 is relatively low. ROA in cluster 1 generates optimal profit, but in clusters 2 and 3 it is less than optimal. BOPO in cluster 1 is able to generate income efficiently by using appropriate operational costs so that bank operations run well, however in clusters 2 to 4 require a reduction in unnecessary operational costs so that the value is not too high. NIM shows quite good results in cluster 1 and overall in Indonesia tends to decrease. CAR in cluster 1 shows that the bank already has the capital to face the risk of loss and overall it is optimal and above the lower threshold value.

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